

A comprehensible popular scientific lecture

“Nuclear radiation is far safer than current regulations suppose”

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For further readable discussion refer to the book:

Radiation and Reason: The Impact of Science on a Culture of Fear

original [paperback](#) (2009), [eReader](#), [Kindle](#) editions
or via Amazon

[Japanese edition](#)

放射能と理性 なぜ「100 ミリシーベルト」なのか
ISBN 978-4198632182 [Tokuma Shoten, July 2011]

Biography, downloads etc.: <http://www.radiationandreason.com>

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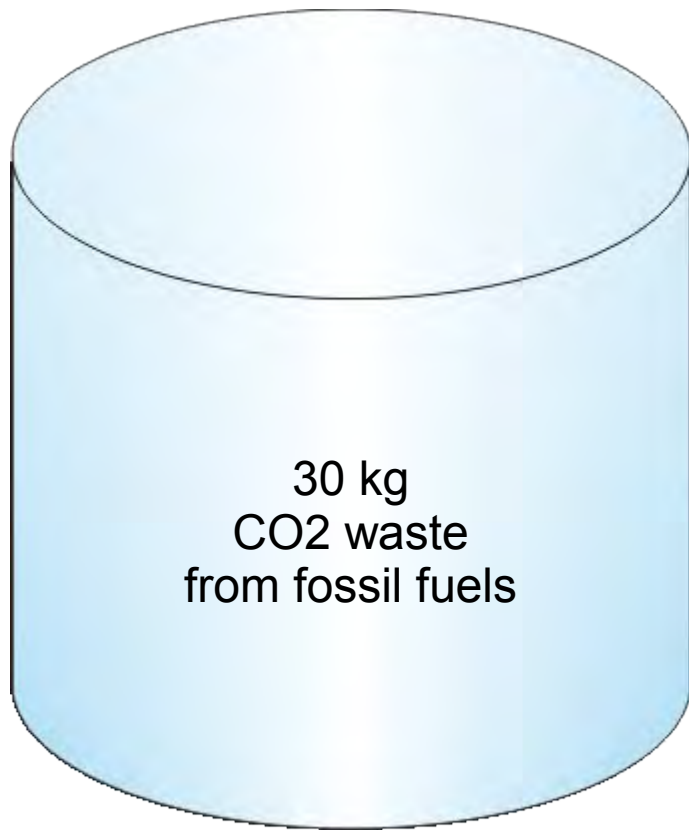
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Why do we need nuclear?

- **more energy and less waste:** million times less than fossil fuel **S4**
- **waste containment:** not released (unlike fossil fuel) **S4**
- **fuel supplies:** from Aus/Can, not Middle East/Russia like oil/gas
- **climate effect:** none (unlike all fossil fuel)
- **output:** high, 24/7, anywhere or weather, (unlike renewables)
- **technology:** safe, available and known, (unlike carbon capture)
- **impact:** compact (unlike windfarms)
- **health impact:** almost entirely the direct and indirect effects of fear of radiation and radioactivity eg waste **S4**, or food **S9** and evacuation **S14** regulations following an accident

What about the nuclear waste?

Canister volumes showing weight of waste per person per day (UK figures)




CO2 and burning: Waste released directly into the air driving climate change. Out of control fires (thermal chain reaction) cause thousands of deaths each year



Faeces and disease: Waste released directly into the environment (water). Uncontrolled disease (biological chain reaction) causes millions of deaths

Nuclear waste: Contained and suitable for safe burial. No increase outside a working nuclear reactor. In 50 years only 50 deaths (Chernobyl).

1/4000 kg 
high level nuclear waste

August 2011

Nuclear Radiation is far safer....

slide 4

Why do people fear radiation?



Basis of this fear:

1. Fear of aftermath of a nuclear holocaust.

An effective Cold War message that frightened everybody at the time.

2. You cannot feel nuclear radiation.

But the cells of your body can - and then repair the damage, too.

S12

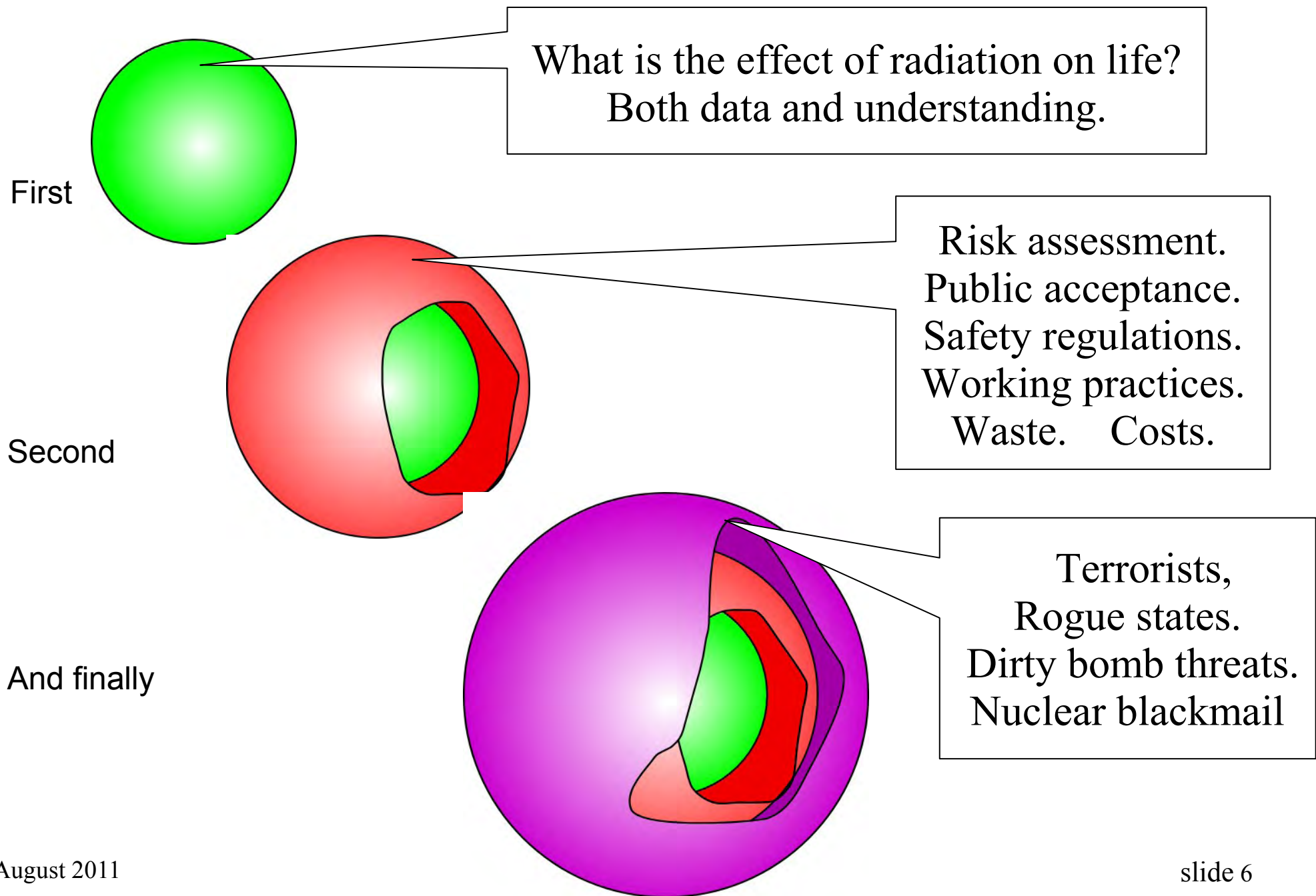
S15

3. The Regulations warn of radiation dangers.

We will look at that. There is a misunderstanding here, for which many of us are responsible, in part.

S18

What is the most important question? All else follows



Radiation doses and dose rates

Consider a paracetamol dose. 100 tablets per person at once is fatal. Two tablets at once cures a headache, without risk, not even 1 in 1000. The doctor may say that 100 tablets in six weeks is OK too. The point is that the dose and the period are both important.

For radiation there is dose (milli-sievert mSv) and dose rate (mSv a month). To find out what dose and dose rate is safe, we need data we can trust.

You can trust radiation doses used in medicine

Today many people benefit from radiation scans and some have radiation therapy for cancer.

CT scans give a dose of 5-10 mSv with an external source of radiation. PET and SPECT scans give a similar dose from an internal injected radioactive source. An advertisement for a PET/CT scan follows (15 mSv for both).

S8

Such radiation and radioactivity, internal and external, is essentially of the same type as that emitted at Fukushima.

A recent public poster

PET/CT がんだック

PET/CT検査とは、

「がん細胞が正常な細胞に比べて多くのブドウ糖を取り込む」という性質に着目した検査です。

この検査では、一度の撮影でほぼ全身をみることができ、PET単独検査に比べて診断精度が格段に向上した「がん画像診断法」です。



料金

94,500円

※出雲市では、2万円を補助する制度があります。

対象者：40歳以上の出雲市民

実施期間：平成23年4月1日～24年3月31日

詳細は健康増進課までお問合わせください。

実施日

毎週月曜日～金曜日

(但し祝日・年末年始は除く)

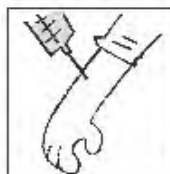
診療の流れ

絶食



検査の6時間以上前から絶食にしてください。ただし、糖分を含まない飲み物（お茶、お水）は飲んでもかまいません。

FDGの注射



FDGを注射します。

安静



薬剤が全身にいきわたるまで、約1時間安静にします。

撮影



排尿後、PET/CTカメラの下で約30分安静にし、撮影します。

診断



専門の医師がPET/CT画像を読影し、総合的に診断します。

PET/CT検査に関するQ&A

Q 糖尿病でも、検査を受けられますか？

A 糖尿病など血糖値が高い方の場合、FDGが筋肉や脂肪へ集積しやすい傾向にあるため、がんへのFDGの集積が低下します。そのため診断精度が下がる場合があります。PET/CT検査が実施できるかどうかについては、かかりつけの医師にご相談ください。

Q 妊娠中や妊娠の可能性のある場合は検査を受けられないのですか？

A FDGは、微量の放射性物質を含んでいますので、妊娠中や、妊娠の可能性のある方は必ずかかりつけの医師にご相談ください。

Q PET/CT検査なら、どんな種類のがんも見つけられるのでしょうか？

A 臓器や部位によっては、発見しにくいがんがあることもご了承ください。FDGは尿中へ排泄されるため、腎臓や膀胱などのがんも発見しにくい場合があります。

発見しにくいがん

膀胱・尿管の癌
腎臓癌
肝細胞癌
胃癌
前立腺癌
(すべての臓器の)微小ながんなど

Q PET/CT検査は入院が必要なのでしょうか？

A FDGを注射してから撮影終了まで、5時間程度ですので、入院の必要はありません。

Food regulations in error, for example caesium in beef

“Measures against Beef which Exceeds the Provisional Regulation Values of Radioactive Cesium by the Government to Ensure Safety of Beef”, issued 27 July 2011

- Eating 1 kg of meat with regulation limit of 500Bq/kg gives a dose of 0.008mSv [page 12, section 4. This number has been checked]
- Exposure lasts over 4 months while the caesium is excreted
- The radioactive caesium dose is evenly spread throughout the body like the radioactive fluorine in a PET radiation scan (called “FDG”) which gives 15 mSv all in a couple of hours **S8**
- Therefore one scan gives the same dose as eating 2000 kg per person of contaminated meat in 4 months. The Regulation is unreasonable
- A similar mistake at Chernobyl was publicly admitted after 16yrs **S10**
- The international safety standard (ICRP) underlying such regulations needs substantial revision **S19**
- But even 15 mSv is far below a dangerous dose... **S11**



The original article was published in Swedish on the 24th April 2002 in Dagens Nyheter, the major Stockholm morning paper. The purpose was to explain to the public how the scientists' evaluation of the disaster has progressed since 1986. The article attracted quite some attention both at home and abroad and sparked a renewed discussion on the subject, so the Swedish Radiation Protection Authority was asked to provide an English translation in order to inform the international audience of its conclusions.

16 years after the Chernobyl disaster, the Swedish Radiation Protection Authority admits:

“We condemned tonnes of meat unnecessarily”

Tonnes of top quality reindeer and moose meat were disposed of unnecessarily in Sweden following the nuclear power accident in Chernobyl on the 26th April 1986. The caesium intervention level for meat set by the authorities was too low. In the slaughter of the same year, 78 percent of all the reindeer meat was destroyed at great cost to the taxpayers and temporary adversity for the reindeer herders. The thinking behind the intervention level was that the individual risk would be so low that the consumer would not need to think about what he or she bought in the shops.

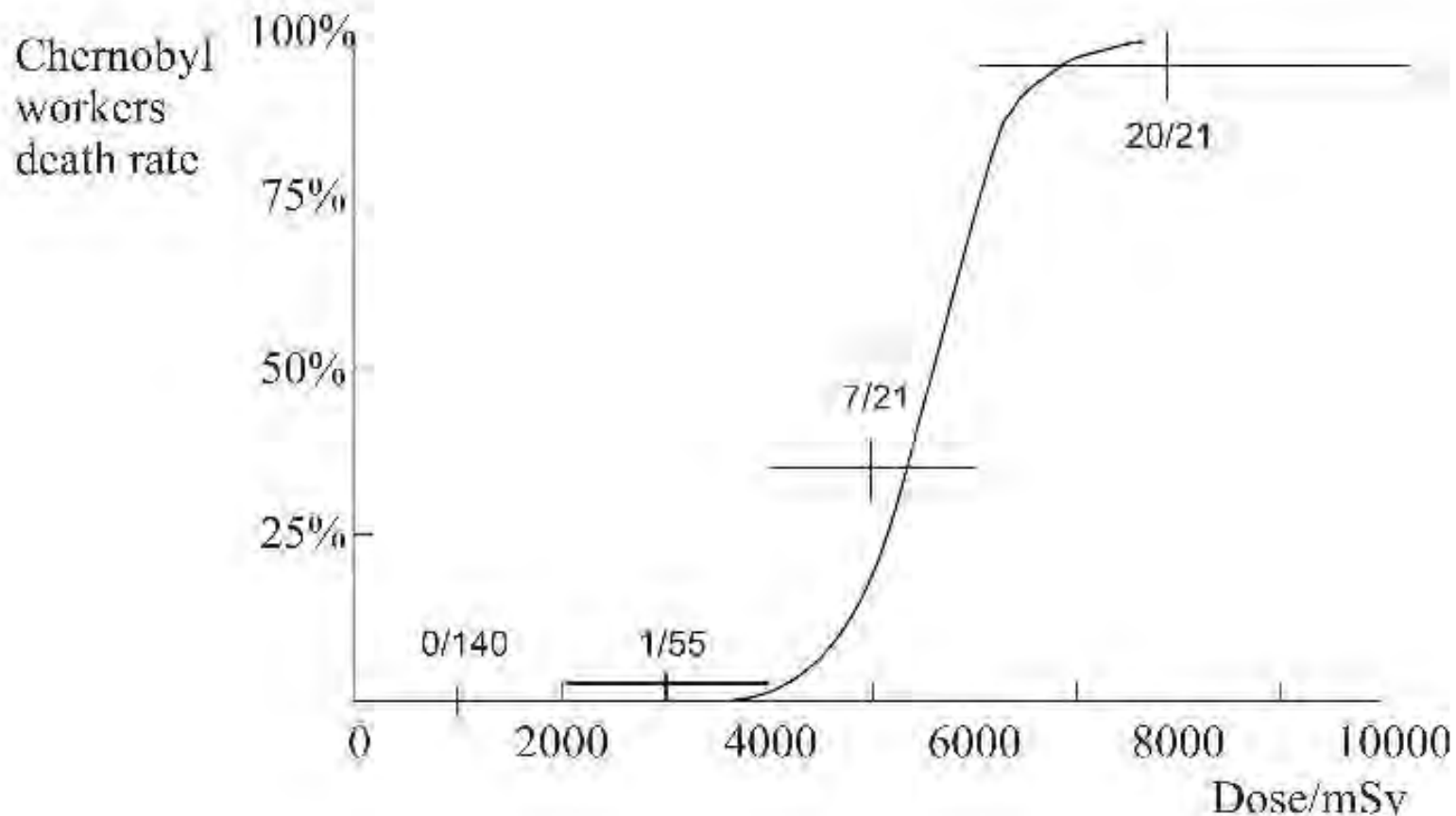
“Perhaps we took on too great a responsibility for the individual consumer,” write the directors of the Radiation Protection Authority.

[signed]

Lars-Erik Holm
Director General
Ulf Bäverstam
Dep. Director General
Leif Moberg
Principal Scientist

Workers at Chernobyl, the initial firefighters

The crosses show the mortality of Chernobyl firefighters (indicated by number who died/total number in each dose range)



above 4,000 mSv 27/42 died from Acute Radiation Syndrome (ARS)

below 4,000 mSv 1/195 died

(the curve is for laboratory rats, shifted a little)

Workers at Chernobyl

Emergency workers who died from Acute Radiation Syndrome (ARS), mostly from a dose above 4000 milli-sievert, did so in a few weeks. No such worker who received less than 2000 milli-sievert died from ARS, although there were 140 of them.

Workers at Fukushima

After six weeks 30 workers had received a radiation dose between 100 and 250 milli-sievert.

Therefore there will be no deaths from ARS at Fukushima

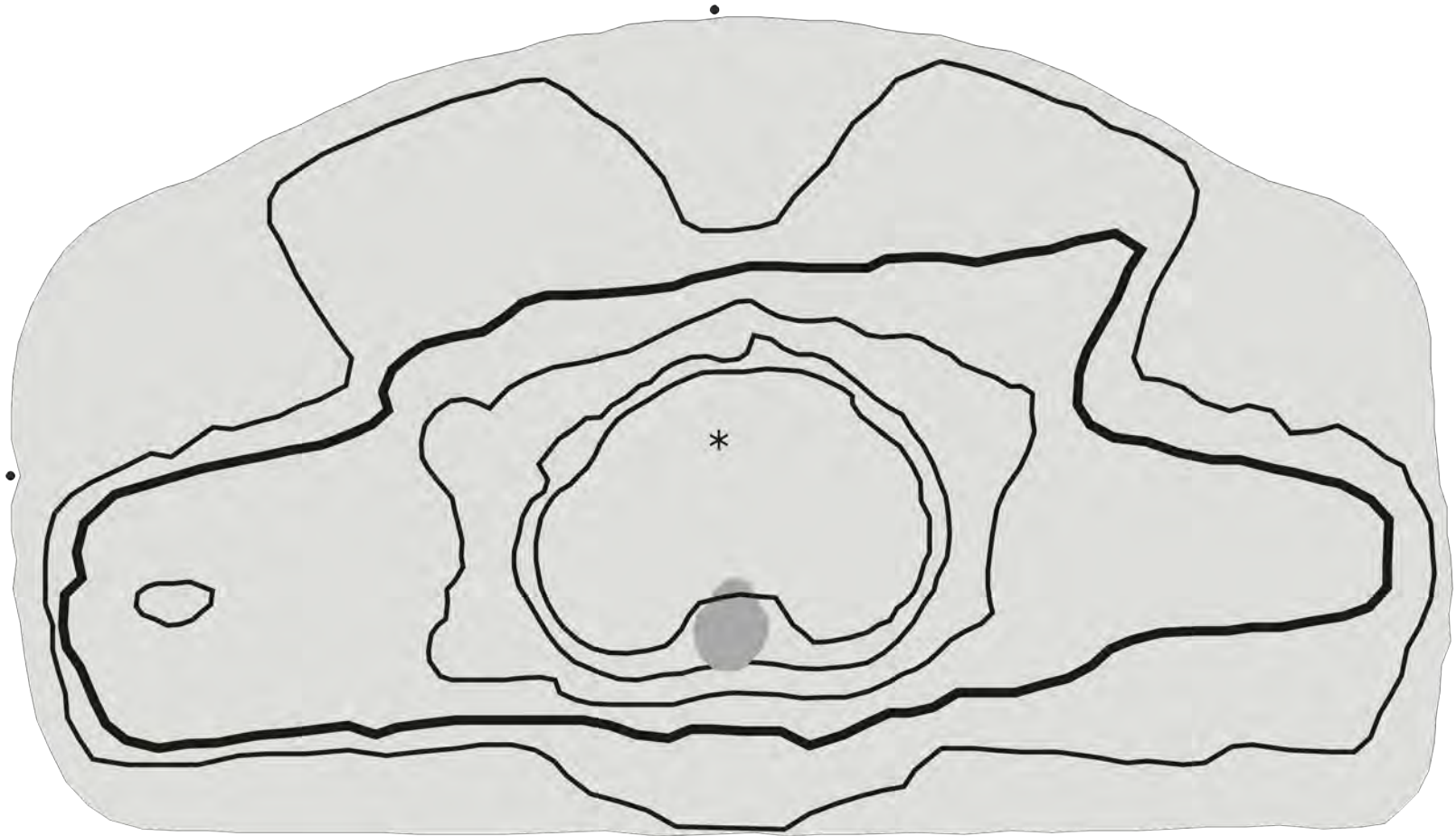
Radiation therapy to cure cancer

Although a single whole-body radiation dose of 4000 mSv is often fatal, patients receiving radiotherapy spread over about 6 weeks to cure cancer get a daily dose of 2000 mSv to the tumour that kills the cancer cells.

S13 They also receive daily 1000 mSv to many healthy organs and tissue that survive; that is more 20,000 mSv per month. Most people personally know someone who has benefited from such treatment.

After each daily treatment healthy organs just have time to repair the radiation damage - and the tumour cells just do not.

Radiation dose contours for an actual prostate cancer treatment plan.
Section of lower abdomen perpendicular to the spine. Rectum shown shaded.
Contours at 97, 90, 70, **50**, 30% of peak dose



[From an image by kind permission of Medical Physics and
Clinical Engineering, Oxford Radcliffe NHS Trust.]

Evacuation guidelines in error

Evacuation at Fukushima

Evacuation criterion was set at 20 mSv per year.

Radiotherapy shows that doses of more than 20,000 mSv per month are tolerable, equivalent to 1000 years at the evacuation criterion.

This criterion is unreasonable.

[Comment: These doses are “per kg” and the repair mechanisms are largely localised, so the fact that the radiotherapy dose is localised, not whole body, could hardly be that significant.]

Evacuation is at least as traumatic as radiotherapy treatment.

The criterion has taken no account of damage to personal and socio-economic health.

Evacuation at Chernobyl

The evacuation (and the advice to the population that their health was threatened by radiation) caused more damage than the radiation itself [UN(2011) and IAEA(2006) reports].

These reports have not been read. The lesson has not been learnt.

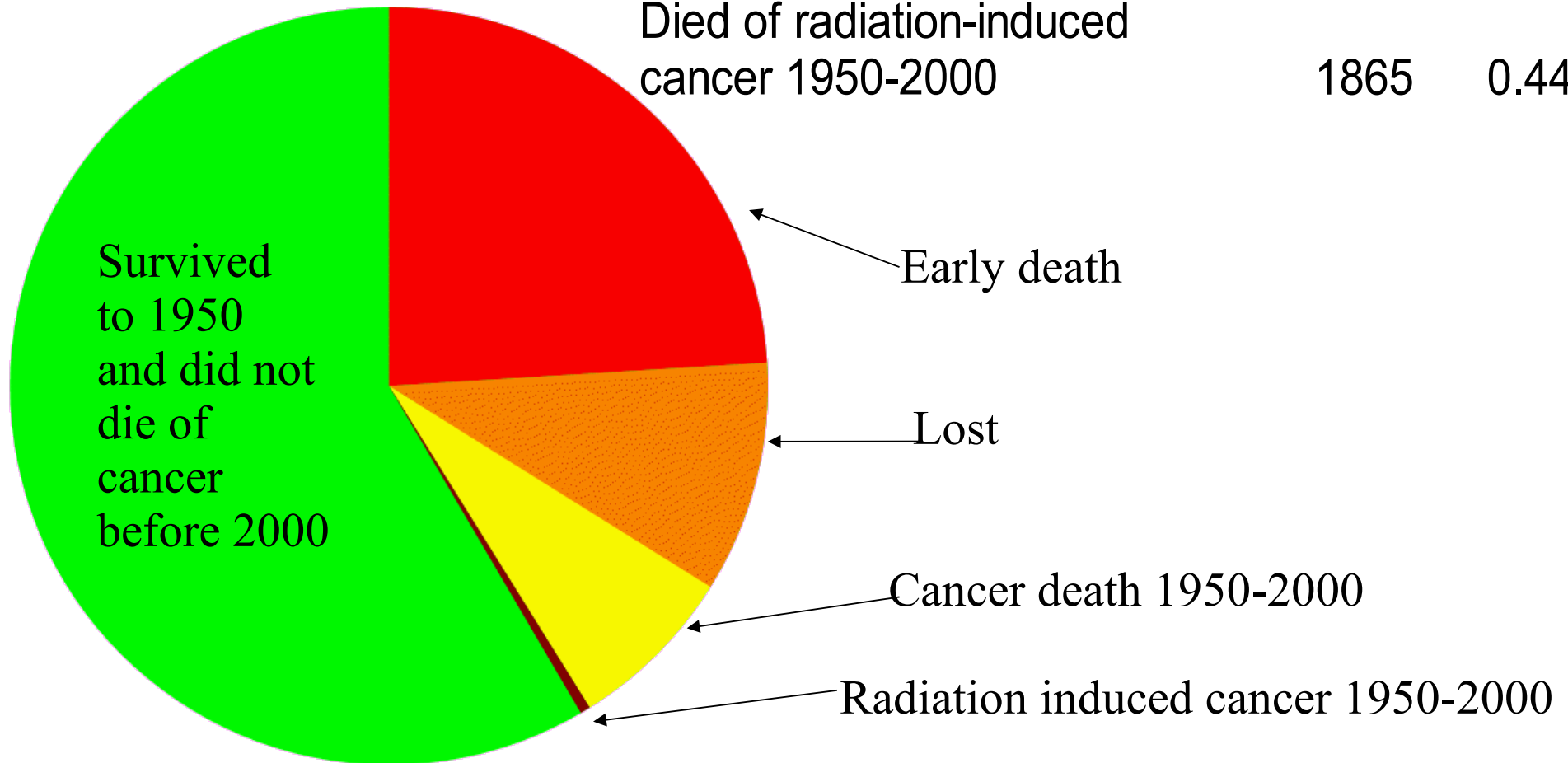
The error has been repeated at Fukushima.

Cancer caused by ionising radiation

- The biological mechanisms that repair radiation damage are ingenious and overlapping, but even acting together they are not perfect.
- When they fail the result can be cancer.
- The ultimate protection is a healthy immune system but this deteriorates with age. So most cancers occur in later years, long after the original dose.
- The various repair mechanisms have evolved to cope with other more frequent attacks on cells, in particular on the DNA.
- It is not possible to distinguish cancers caused originally by radiation.
- To detect radiation-induced cancer the lifelong health records of a large population who suffered a large radiation dose must be compared with those of a similar population who were not irradiated.
- This has been done for cancer fatalities among the survivors of Hiroshima and Nagasaki for the period 1950-2000. **S16**
- The average dose was 160 mSv. For doses greater than 100 mSv there was a clear increased risk of cancer; but not for those less than 100 **S17**
Any such risk is less than the chance of a road death in 50 years [USA]
- Overall the risk was 1 in 15 higher than in similar populations not irradiated

What do we know from Hiroshima and Nagasaki?

Total population	429000	100.00%
Known killed or died 1945-1950	103000	24.01%
Lost or died 1945-1950	43000	10.02%
Survived to 1950	283000	65.97%
for whom dose known	86955	
Died of cancer 1950-2000	32057	7.47%
Died of radiation-induced cancer 1950-2000	1865	0.44%



Solid cancer deaths among Hiroshima and Nagasaki survivors,
1950-2000, separated by dose range (Preston et al., 2004)

Dose range mSv	survivor number	solid cancer survivor actual	deaths 1950-2000 expected	extra risk per 1000
less than 5	38507	4270	4282	-2.0 to 1.4
5 to 100	29960	3387	3313	0.0 to 3.5
100 to 200	5949	732	691	3.5 to 12.5
200 to 500	6380	815	736	9 to 18
500 to 1000	3426	483	378	25 to 37
1000 to 2000	1764	326	191	63 to 83
above 2000	625	114	56	72 to 108
all	86611	10127	9647	5.0 to 5.2

“expected” means the number of deaths predicted from those in other cities
 Lines highlighted in green have doses compatible with zero risk, final column

What is wrong and who is to blame?

Safety regulations at Fukushima have caused unjustified damage to the local economy and hardship and suffering to the population

- In every country such regulations are based on advice from the International Committee on Radiological Protection (ICRP)
- This advice is at fault. Its caution is unbalanced. It treats radiation as a special case and ignores other sources of danger and also the established repair of radiation damage for doses spread in time. **S12**
- ICRP has given advice to reduce radiation exposure As Low As Reasonably Achievable (ALARA), that is close to natural levels of a few mSv per year. This is a level for reassurance, not for safety
- ALARA is what a radiation-phobic world asked for, as we marched, protested and petitioned political leaders in the 20th century. That was our mistake, not that of the Japanese Government nor the ICRP. But now we should correct the error
- We need safety levels that are As High As Relatively Safe (AHARS), where “relatively” refers to competing dangers (as in medicine)
- What might such AHARS levels be? **S20**

A lesson from history: repeal the “Red Flag Act”!

It is reported that places have been found at the Fukushima plant where the radiation level exceeds 10 sievert per hour. Indeed such a level would be lethal in 30 minutes.

This is neither surprising nor alarming. Driving on the road, there are places not 10m away (in front of oncoming traffic) which are equally dangerous - but we learn not go there.

In 1865 concern about the safety of (steam) road traffic rose to the point that the speed limit was lowered to 4 miles an hour and a man had to walk in front with a red flag (UK/US). This safety act was supported by the railway industry (of course) and public concern about horses.

Fortunately for world prosperity, in spite of public protests, these acts were repealed in 1896. We have learnt to live with the dangers and unquestionable benefits of road traffic.

Today we should reverse our “Red Flag” attitude to nuclear radiation and radioactivity. It needlessly hampers prospects for world prosperity.

But what should be the radiation “speed limit”?

That is, at what level should radiation safety regulations be set?

We compare monthly radiation doses as graphical areas...

How many will die from radiation at Fukushima?

It is very unlikely that anyone will die from radiation as a result of Fukushima, even over the next 50 years. Here is why.....

After six weeks 30 workers had received a radiation dose between 100 and 250 milli-sievert. At Chernobyl no emergency worker who received less than 2000 milli-sievert died from Acute Radiation Syndrome, although there were 140 of them. **S11**

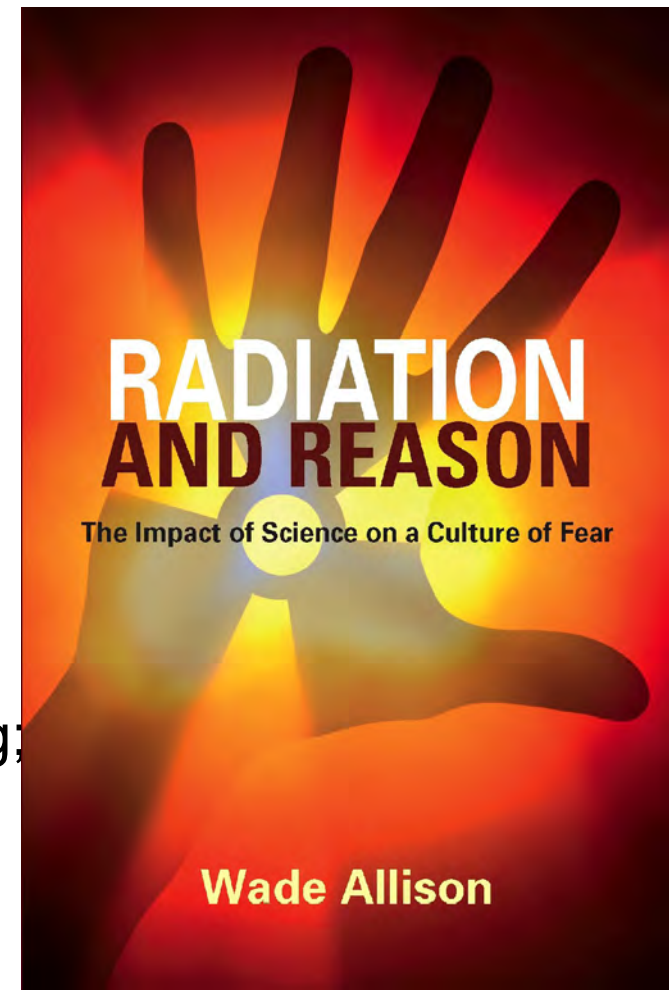
At Hiroshima and Nagasaki, out of 5949 citizens who received a dose in this range, 41 contracted radiation-induced cancer in 50 years -- that is 1 in 150. **S17** So the chance that ANY worker at Fukushima will contract extra cancer is less than 25%. Doses to the public have been far lower and so without risk.

Near Fukushima seaweed is part of the diet and many children received iodine tablets. At Chernobyl, an iodine-deficient region, 6000 children contracted thyroid cancer but just 15 died. None are expected to die at Fukushima.

There are those who prefer to spread alarm and fear, but this is quite unjustified and they will have to answer to the Japanese people

What needs to be done for the future?

- fear is deadly** - after Chernobyl there were 2000 extra induced abortions in Greece, far away from any radiation;
- radiation is not incredibly dangerous** - it cures many 1000s of cancers every year;
- education** is needed to explain radiation in simple words - it is not so difficult;
- regulation for actual danger**, not fear based on unquantified aversion, affecting simply solvable tasks, like waste and decommissioning;
- there are bigger threats**: climate change, food, socio-economic stability, population, geology, water;
- consider new nuclear** for the sake of the environment, electricity, desalination, food irradiation



We may hope to solve the problems of the 21st century, provided that we re-assess our 20th century worries. This requires trust, discussion, thought, education and reform